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# Label-Free Nanoscale Visualization of Nanoplastic, Detection and Trafficking in Human Cells

The widespread presence of plastic and its degraded forms, known as micro- and nanoplastic, has become an increasing concern due to its impact on the environment and on human and animal health. Owing to their small dimensions, nanoplastics can enter the food chain and pose potential risks to human health. Therefore, early detection of nanoplastic at the trace level and understanding its cellular interactions and fate are essential in evaluating its health impact. Raman spectroscopy is a very useful non-invasive tool that has been used for plastic detection. However, fundamental limitations of normal Raman spectroscopy, in terms of limited spatial resolution, hinder the collection of chemical information from nanoparticles and at the trace level.

With the help of tip-enhanced Raman spectroscopy (TERS), [1] we demonstrated targeted single particle detection of nanoplastic spheres of polystyrene (PS) and polyvinyl chloride (PVC) in MCF10A human mammary epithelial cells. The combination of TERS with atomic force microscopy enabled the direct visualization of individual nanoparticles with molecular and cellular target specificity, distinguishing them from the surrounding cellular matrix. With the help of electron microscopy and AFM imaging, the intracellular localization of PS nanoparticles and their trafficking through cellular compartments were revealed with a spatial resolution of less than 30 nm. PS and PVC tend to accumulate in the cytoplasm through endosomal compartments instead of random localization in the cytoplasm. PS tends to accumulate as small aggregates compared to PVC, where particle aggregation forms large vesicle-like structures. This observation further explains and supports the higher toxicity of PVC (60%) nanospheres compared to PS (85%), as documented from a cell viability study. It is anticipated that nanoparticles trapped in large vesicle-like structures could interfere with endocytosis and cause mechanical stress, triggering a stress response. [2] The study highlights the behavior of nanoplastic in the cellular environment, taking the example of nanospheres of PS and PVC, while demonstrating the power of TERS as an analytical tool for label-free chemical identification of nanoplastic at targeted locations in the cellular environment with single-nanoparticle sensitivity.

## References

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